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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Early Survival and Growth of Ponderosa Pine Provenances in East-Central Kansas¹

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A provenance test of 78 sources of ponderosa pine (*Pinus ponderosa* Laws.) was established in 1968 near Junction City, Kansas. Initial adaptation and performance were evaluated from 6-year data on survival and growth. Progeny of sources in the Pacific Northwest and the southern Rocky Mountain regions performed poorly. Early growth appears to be clinally related to elevation of seed provenances. These preliminary results indicate that ponderosa pine planting stock for east-central Kansas should be grown from seed collected in the north-eastern range of the species.

Keywords: *Pinus ponderosa*, provenance study, Great Plains.

Introduction

Ponderosa pine (*Pinus ponderosa* Laws.) is the most important pine species in western North America, and is commercially important in most States west of the Great Plains (Harlow and Harrar 1958). Its natural range (fig. 1) extends from British Columbia southward into northern Mexico, and from California eastward into the Great Plains, except Kansas (Critchfield and Little 1966).

Ponderosa pine has been planted extensively both in and outside its natural range. In the midwest it has been used in ornamental, windbreak, Christmas tree, and forest plantings. Unfortunately, few records of seed origin or performance have been maintained. Now, however, a 10-acre planting of more than 4,000 trees from 78 provenances (seed origins) grows near Junction City, Kansas (fig. 1). One of the long-range objectives of this study is to evaluate source performance, so that selection of seed for stock to be planted in central Kansas will be from best-adapted sources. Survival and height growth at age 6 have been used to evaluate early performance. The results presented here therefore should be regarded as preliminary, because early performance does not necessarily predict long-term results.

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Methods and Materials

Seeds for this study were collected from at least 10 trees at each of 78 locations during 1962, 1963, and 1964. Trees were selected at random (not based on phenotype) to get good representation of germ plasm at each location. Seeds were sown in 1965 at the USDA Forest Service Bessey Nursery at Halsey, Nebraska. Seedlings were allowed to grow two seasons in seedbeds and one season in transplant beds. In 1968, 2 + 1 stock was planted below Milford Reservoir, near Junction City, Kansas, in loamy sand in the Republican River drainage area. The outplanting consists of a randomized complete block design, with individual four-tree linear plots for each of 78 sources, replicated in each of 15 blocks. This plantation is one of 13 established in the Great Plains States by the cooperative efforts of State Agricultural Experiment Stations and the Rocky Mountain Forest and Range Experiment Station Research Work Unit at Lincoln, Nebraska.

Survival percentages were recorded in 1968, 1969, and 1973. Heights to the nearest centimeter were recorded in 1968 and 1973, and the average of each four-tree plot was calculated.

Results and Discussion

Survival

Analyses of survival data for all years indicated significant differences among both provenances and blocks. Blocking effects are believed to have resulted from differences in time of spring planting. Planting required approximately 40 days, and survival declined directly with lateness of the date that blocks were established.

Average survival of all provenances has been quite high (table 1). Source 868 (California) failed

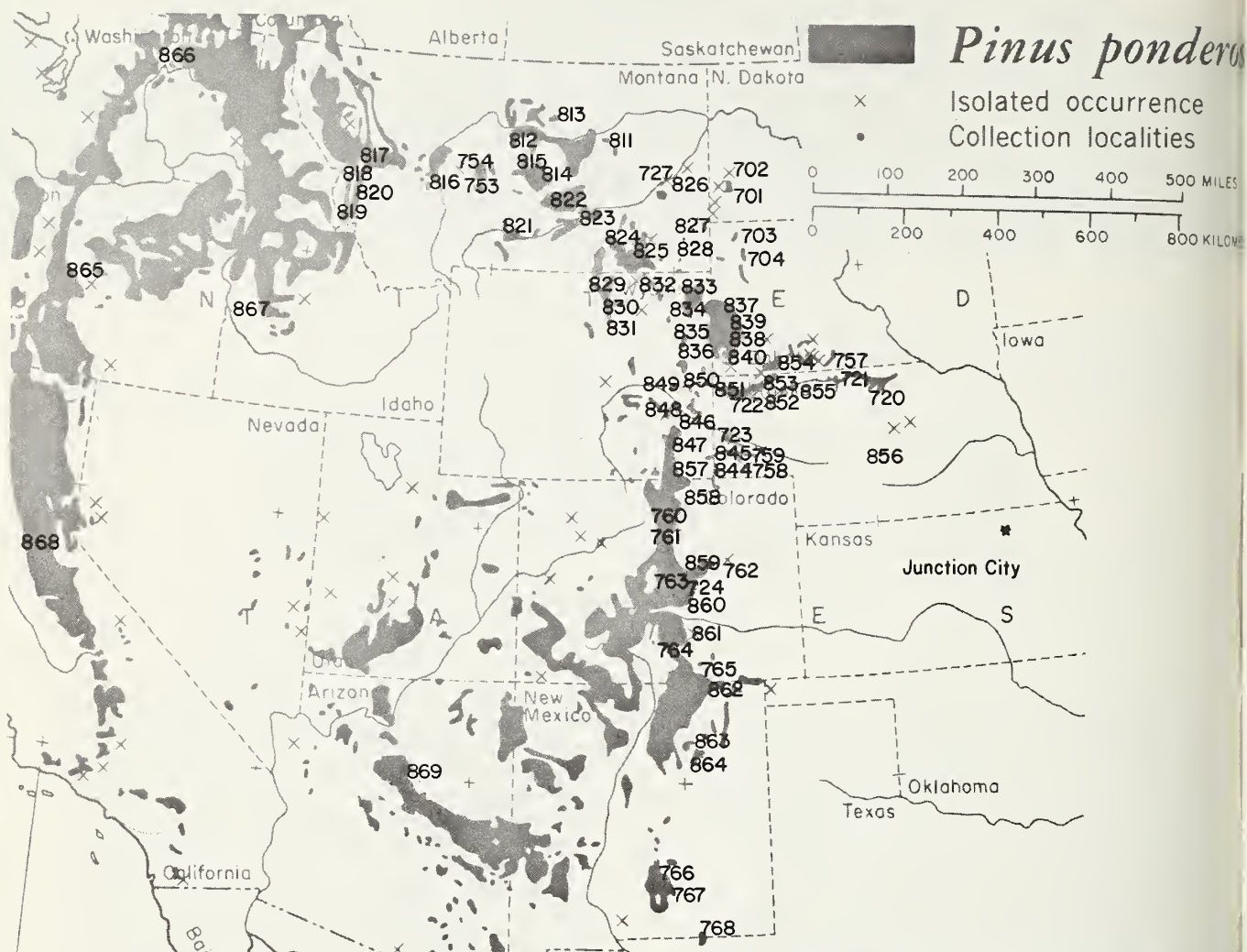


Figure 1.—Collection locations of ponderosa pine for Kansas provenance test initiated in 1968 near Junction City, Kansas. (Distribution map from Critchfield and Little 1966.)

Table 1.—Kansas ponderosa pine provenance trial: provenance location data, and survival and height growth

Origin	Source data				Survival			Height growth	
No.	Location	Latitude	Longitude	Elevation	1968	1969	1973	1973 height	1968-73 growth
		°N	°W	m	- - - percent - - -			cm	cm
FAR WEST:									
866	WA	48.3	111.9	488	77	73	73	78.5	53.8
867	IO	44.0	116.0	1036	73	70	50	63.8	43.1
868	CA	38.6	120.7	762	0				
BITTERROOT VALLEY:									
817	MT	47.0	113.7	1036	65	60	48	70.2	55.8
818	MT	46.7	114.2	1433	65	53	40	62.5	47.9
819	MT	45.9	114.2	1250	63	58	58	62.6	44.6
820	MT	46.2	114.0	1372	85	83	75	67.3	49.5
NORTH CENTRAL MONTANA:									
816	MT	46.6	111.8	1372	100	98	95	97.6	77.8
754	MT	47.1	110.8	1372	97	93	93	96.8	78.3
815	MT	47.1	109.2	1463	88	87	87	75.0	59.2
814	MT	47.1	109.0	1128	75	75	75	82.9	66.4
812	MT	47.5	109.5	1036	88	88	88	99.9	78.9
813	MT	47.9	108.6	1433	97	95	93	92.9	75.0
811	MT	47.6	106.9	884	98	98	95	108.1	86.9

Table 1.--Kansas ponderosa pine provenance trial:
provenance location data, and survival and height growth (continued)

Origin	Source data				Survival			Height growth	
No.	Loca- tion	Latitude	Longitude	Eleva- tion	1968	1969	1973	1973 height	1968-73 growth
<hr/>									
°N °W m - - - percent - - - cm cm									
SOUTHERN MONTANA:									
821	MT	45.8	109.0	1158	95	93	93	98.7	80.7
822	MT	46.2	108.4	1158	93	93	93	106.2	83.8
823	MT	46.1	107.4	884	95	93	88	109.3	87.9
824	MT	45.9	106.6	1036	93	93	88	96.3	79.5
825	MT	45.7	106.0	1097	97	95	95	112.9	91.7
MISSOURI PLATEAU:									
727	MT	46.9	105.2	808	77	75	75	76.7	57.9
826	MT	47.0	104.7	838	90	82	75	89.1	74.3
702	ND	46.9	103.5	762	90	90	90	87.9	69.5
701	ND	46.6	103.4	792	90	90	88	91.4	70.1
827	MT	45.8	104.5	1158	100	100	97	100.5	79.3
828	MT	45.6	104.1	1219	100	98	95	105.3	85.5
703	SO	45.8	103.5	975	93	90	90	89.9	70.7
704	SO	45.6	103.2	1052	97	97	97	97.6	77.8
BIGHORN MOUNTAINS:									
829	WY	44.8	107.3	1554	95	93	90	89.4	73.3
830	WY	44.6	107.1	2134	93	93	92	69.1	53.8
831	WY	44.2	106.8	1768	93	93	87	91.7	75.2
BLACK HILLS:									
832	WY	44.9	105.6	1189	95	95	95	97.1	79.6
833	WY	44.6	104.3	1219	95	95	95	89.9	69.7
834	WY	44.4	104.4	1676	92	90	90	91.6	72.1
835	WY	43.9	104.2	1548	98	97	92	90.3	71.7
836	WY	43.7	104.1	1244	93	92	85	84.1	67.5
837	SO	44.3	103.8	1920	97	97	90	97.9	77.9
838	SO	43.9	103.6	1731	82	82	82	92.4	74.3
839	SO	44.2	103.6	1646	62	62	62	84.4	65.6
840	SO	43.7	103.4	1280	85	85	83	87.1	66.7
PINE RIOGE AND NIOBRARA RIVER:									
849	WY	42.8	105.0	1584	95	92	88	87.3	70.4
850	WY	42.9	104.4	1524	95	95	90	97.3	77.6
851	NE	42.7	103.6	1280	92	92	92	92.1	70.9
722	NE	42.7	103.1	1311	90	90	90	92.7	70.5
852	NE	42.5	102.5	1158	97	95	93	99.8	78.8
853	NE	42.9	102.5	1097	95	95	95	108.6	86.3
854	SO	43.2	101.7	1006	87	87	78	93.3	73.8
855	NE	42.8	101.7	975	85	78	77	96.9	78.6
757	SO	43.2	101.0	792	92	88	88	111.5	91.7
721	NE	42.9	100.6	823	70	70	70	112.3	95.8
720	NE	42.7	99.8	701	90	90	90	123.7	103.6
NORTH PLATTE RIVER AND LOOGEPOLE CREEK:									
848	WY	42.6	105.7	2103	92	90	90	70.9	54.4
847	WY	42.2	105.2	1676	93	90	75	72.7	56.2
846	WY	42.2	104.5	1280	98	98	90	102.7	82.4
723	NE	41.8	103.8	1402	97	93	93	98.9	78.5
845	NE	41.5	104.0	1554	82	82	82	76.9	61.0
844	NE	41.2	104.0	1585	88	88	82	68.6	53.2
758	NE	41.2	103.2	1372	87	83	83	84.5	68.0
759	NE	41.4	103.1	1311	87	87	87	90.9	70.1
856	NE	41.4	100.0	884	68	68	62	84.9	65.5
FRONT RANGE - NORTHERN COLORADO:									
857	WY	41.2	105.3	2347	100	100	95	79.9	63.9
858	CO	40.5	105.1	1615	90	90	88	91.3	71.8
760	CO	40.2	105.5	2560	95	95	95	77.0	62.8
761	CO	40.0	105.4	2438	90	88	88	77.1	60.1
859	CO	39.4	104.7	1981	82	80	68	70.8	54.7
762	CO	39.4	103.8	1798	78	75	75	74.7	60.1
724	CO	39.1	104.6	2256	88	87	83	84.5	66.8
763	CO	39.1	105.1	2377	78	78	78	79.6	63.7
860	CO	38.6	104.9	1981	77	75	72	87.4	69.3
FRONT RANGE - SOUTHERN COLORADO AND NORTHERN NEW MEXICO - ARIZONA									
861	CO	37.9	104.9	2012	98	98	92	90.0	71.9
764	CO	37.9	105.2	2682	95	92	92	98.6	83.0
765	CO	37.3	104.7	2134	93	93	93	107.6	84.5
862	NM	36.9	104.3	2240	95	93	88	90.8	70.0
863	NM	35.8	105.0	1951	73	73	73	81.0	62.0
864	NM	35.5	105.3	1951	60	53	53	87.4	67.7
869	AZ	35.2	111.8	2134	55	55	55	93.5	75.5
SOUTHERN NEW MEXICO:									
766	NM	33.3	105.6	2225	8	8	8	65.9	50.2
767	NM	33.0	105.4	1951	52	47	47	80.7	60.2
768	NM	32.2	104.8	1768	55	55	55	90.2	66.9
Mean					84.5	82.9	80.3	89.3	70.8
Standard deviation					17.8	18.1	18.4	21.4	19.9

completely the first growing season. Source 766 (New Mexico) also performed poorly. Generally speaking, survival was lowest in sources from west of the Continental Divide and from the southern Rocky Mountains. Survival problems in the southern sources may have resulted from unfavorable top/root ratios, since these sources were the tallest transplants, yet were dug at uniform depth.

Survival of progeny derived from natural stands in southeastern Montana, eastern Wyoming, North Dakota, South Dakota, eastern Colorado, and Nebraska was generally very good. The exception was source 856 in central Nebraska, the provenance nearest to the Kansas plantation site. Sources that survived best were from diverse locations throughout the northeastern part of the species range. Thus no well-established patterns were evident to relate survival to latitude or elevation of parent stands. Differences may become apparent in time.

Height Growth

Analyses of growth data showed significant source effects. Average growth of all sources at 6 years was 70.8 cm (table 1). As with survival, sources west of the Continental Divide and from the southern Rocky Mountains grew the least (table 1). Most growth was made by sources 720, 721 (Nebraska), 757 (South Dakota), and 811, 825 (Montana). Parent stands of sources 720 and 721 (Nebraska) and 757 (South Dakota) are at low elevations, and represent the easternmost extent of

the species' natural range at mid-latitude of about 43° (fig. 1).

Growth data for sources east of the Continental Divide, which are known as the Interior variety (*Pinus ponderosa* var. *scopulorum*), were subjected to stepwise multiple regression analysis to determine if location and climatic variables could explain differences in growth. The variables were latitude, elevation, average annual precipitation, average annual temperature, and length of growing season. Sources 817, 818, 819, and 820 from western Montana, source 866 from Washington, and source 867 from Idaho were omitted from this analysis, because they belong to the distinct, well-recognized Pacific Coast variety (*Pinus ponderosa* var. *ponderosa*).

Results of the regression analysis indicated that only one variable, elevation, was significantly (inversely) associated with growth. It accounted for approximately 25 percent of the source growth variation ($R = -0.50$). In general, sources from lower elevations grew faster (fig. 2). Others have reported similar results with ponderosa pine (Mirov et al. 1952, Callaham and Hasel 1961, Squillace and Silen 1962, and Hanover 1963).

Summary

To assure good survival and growth of ponderosa pine in central Kansas, it appears that seed should be obtained from stands in the northeastern part of the species range east of the Continental Divide and from low elevations. A particularly promising location appears to be that of provenances 720, 721, and 757 in north-central Nebraska and adjoining South Dakota.

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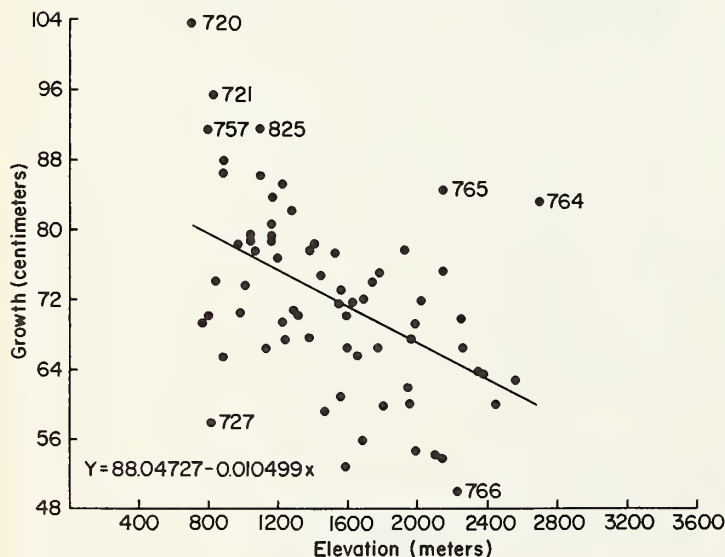


Figure 2.—Ponderosa pine in Kansas: 1968-73 growth related to elevation of seed source.